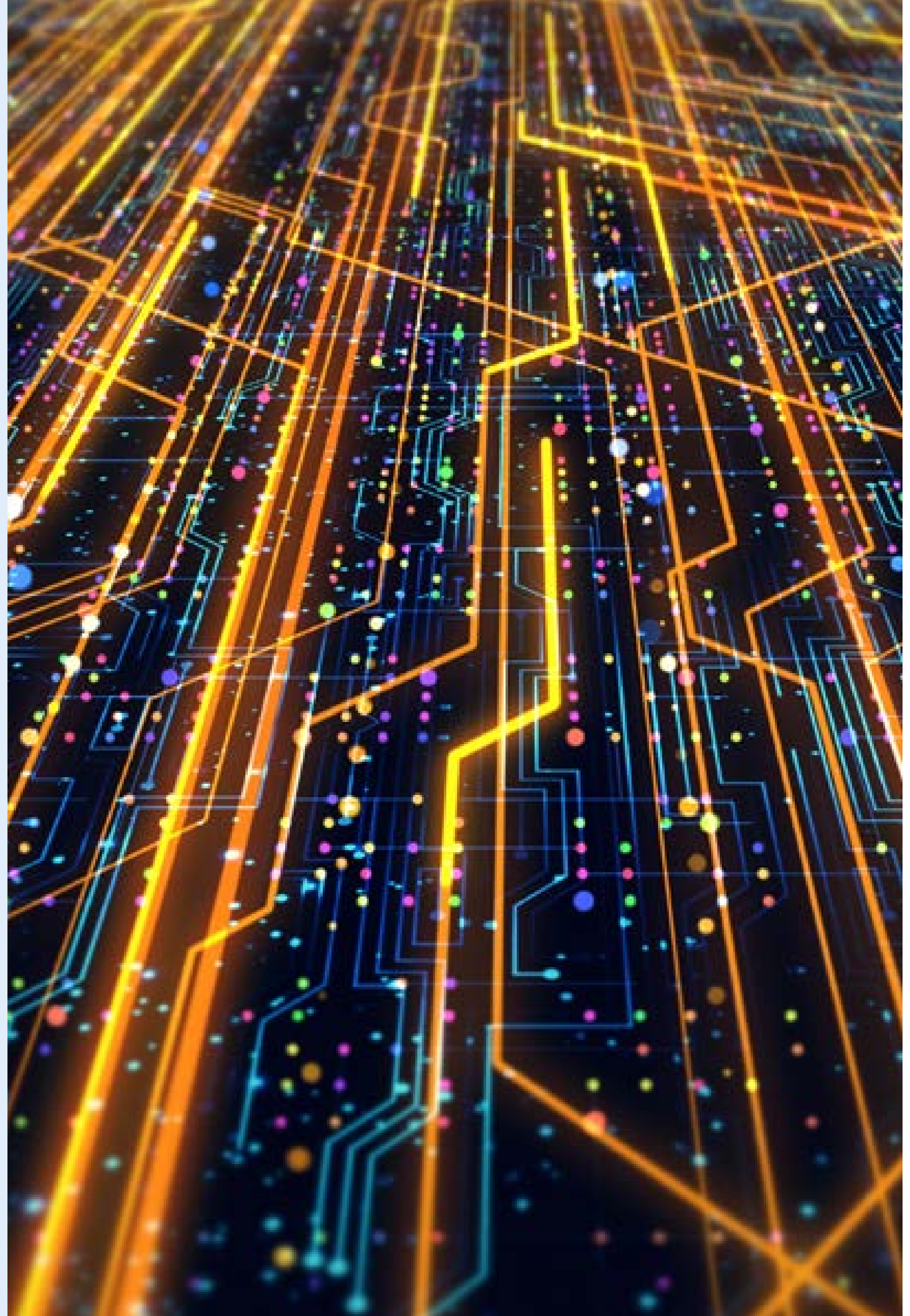
PEDESTRIAN DYNAMICS®

Product Brochure

INCONTROL

Index



1. Introduction

Established in 1989, InControl is a global simulation software company offering Digital Twin Software Solutions for Material Handling and Logistics, Manufacturing, Transporation, Leisure Venues and Metropolitan Areas. By mirroring the flow of people and goods through large-scale infrastructures, we help our clients to keep their customers, employees and environment Safe and Sustainable. Based on our Software Platform we deliver our customers data, graphs, and insights to analyze and improve their complex infrastructures and processes.

Our Digital Twin Software Solutions are implemented across various businesses, organizations, universities and research and development insitutes worldwide. Clients use our Software Platform to simulate large-scale logistic systems and infrastructures such as baggage handling systems, container terminals, train stations, assembly lines, football stadiums, and arenas. Our software solutions play a vital role during all phases, from design to implementation and operations.

AGENT BASED SIMULATION SOFTWARE

For all leading architects, engineers, and consultants performing crowd risk analysis. Our crowd management simulation software Pedestrian Dynamics® is a state-of-the-art simulation environment designed to model any kind of pedestrian infrastructure or environment. Our software contributes to the customer experience, (cost) efficiency, innovation, safety, and security of your event.

Pedestrian Dynamics®:

- Offers a rapid model building environment which saves time and costs. Only a few steps are required to model the most complex operations.
- Is flexible, robust, and easy to use.
- Has been used widely in many large-scale projects in most critical infrastructure environments including stadiums, airports, public transport terminals, mega- events and urban planning.

Pedestrian Dynamics®
Crowd Simulation Software

With InControl software you can predict and control all kind of scenarios, or as we say: it enables you to

Experience the Future Today!

2. Features

USING PEDESTRIAN DYNAMICS®

When the scope and purpose have been defined, performing and evaluating a crowd simulation can in general be divided in four phases. The following unique features of Pedestrian Dynamics® support you in each of these phases.

2.1 Fast model creation

TRAINING, SUPPORT & HELP

Video and written tutorials will help you get started with the software.
Training and support is available to help you to quickly learn more advanced modeling techniques and get the most out of your crowd simulations.

EXPLICIT CORRIDOR MAP

By applying Explicit Corridor Map (ECM) technology the software automatically creates a unique innovative data structure which represents the continuum walkable space of a multi-layered environment. This state-of-the-art technology originates from the advanced gaming industry and allows Pedestrian Dynamics® to quickly steer and generate paths for a large number of people.

MODEL IMPORT

Object import enables you to build your environment automatically from a file, e.g. CityGML, BIM, CAD/DXF, XML, ADO, ActiveX, 3DS and many other industry standards. This significantly reduces the time to build up your model.

VISUALIZATION

- Model your people with simple 3D models or detailed skeletons.
- Walk through your digital environment using Oculus.

DRAWING TOOLS

Contains an extensive set of drawing tools to create, modify and classify infrastructural elements and activity locations within an environment. Graphical user interfaces are used to modify specific properties.

2.2 Domain specific elements

STADIUM ELEMENTS

The stadium elements enable you to model tribune stands. You can develop a complete stadium model, by analyzing the crowd flows from the entrance to the seats.

TRANSPORTATION ELEMENTS

Transportation elements enable you to model the arrival and departure of transportation objects like trains, buses, trams. Including the boarding and disembark behaviour of the passengers. You can develop complete railway station models.

2.3 Scenario Preparation

AUTONOMOUS AGENTS
People are represented by autonomous agents. Each agent contains unique properties and preferences which are generated from an agent profile that can resemble a certain group of people. For example groups with a certain age, commuters, shoppers etc. Profiles based on research data to describe these groups are available.

The intuitive graphical user interface makes it easy to define group profiles with predefined rules as well as user defined rules.

ACTIVITY PLANNING AND SCHEDULING
The global routing of people is based on activity planning and scheduling. Within the simulation people are routed between a start and goal location.

PARAMETERS AND SCENARIO MANAGEMENT
Parameters can be used to model different scenarios in one model. These scenarios can be easily created and maintained using the Experiment Wizard. You do not have to define required output in advance of running the scenarios. This all save you valuable modeling and experimentation time.

PROGRAMMING LANGUAGE TO CUSTOMIZE YOUR MODEL
Besides a large number of predefined rules all settings are fully customizable. The powerful and easy to use scripting language **4DScript** gives you the possibility to easily define your own rules and settings.

2.4 Simulation and Visualization

LARGE CROWDS
Dynamic routing and steering of a high volume of people.

MODIFY ON THE FLY
Change the settings of your model on the fly during the simulation.

AGENT BASED AND DISCRETE EVENT SIMULATION
Combines agent based and discrete event simulation. Autonomous agents are routed through a continuum space while discrete events are used to control other occurrences like activity properties, train arrivals and incidents.

DYNAMICALLY CHANGING CONDITIONS
Adaptation to dynamically changing (local) conditions. As in reality the situation can change during the simulation. The ECM data structure can be updated locally in real time. This allows the modelling of changing weather conditions like rain, collapse of a part of a building, incidents, partly blocked routes and many other incidents or situations that can occur during the simulation run.

FAST SIMULATION RUNS
Fast simulation runs by taking advantage of multi-threaded computing and with a 64-bit simulation engine, you are able to run 100.000 agents in real time.

2D & 3D VISUALIZATION
Instant 2D & 3D visualization showing you results right away.

2.5 Analysis

FOOTSTEP LOGS
Automatically save a great number of statistics including footstep logs. Consequently, results can be defined, analysed and compared even after a scenario has been completed without having to re-run scenarios.

MOVIE
Easy movie playback and recording.

OUTPUT MODULE
The integrated output module allows you to create all kind of maps and graphs that give you a clear picture and better understanding of the safety and experience of the crowd.

The following output can be generated:

- A frequency map is a chart showing the number of agents that passed a certain area.
- A density graph shows the density experienced for a chosen period of time for a specific area.
- A density map is a chart showing the maximum average density per time interval. It shows the crowdedness.
- A travel time map is a chart showing the travel time of each agent from its starting location using a colored scale.
- A flow counter graph is a line that shows the number of agents that have crossed this line for both directions.
- Travel time histogram shows the travel time between two locations. This can, for instance, be used for analyzing the evacuation time.
- Walking distance statistics show the walking distance of agents.
- Delay times statistics show you how much delay and waiting time agents experience on a route and in queues.
- Travel experience statistics show you the percentage of the total walking time that an agent experienced within a certain local density.
- Maximum content statistics show you the maximum number of agents on a route.
- Filters and breakdown of results show you the results for specific profile ID's, height layers or route steps. This enables you to do a more detailed analysis of specific routes and agent profiles.
- Data export features enable you to export pictures and other results to enhance your reports.

3. Licensing

Pedestrian Dynamics® offers an all-inclusive subscription based licensing model with the following benefits:

- Product updates - All new product release and updates will be available for you.
- Flexible subscription - The Software can be activated on a monthly or yearly subscription basis to address your business needs.
- Network capabilities - The Software can be used on a standalone base or via network 'floating' licenses to enable concurrent users access the software from multiple locations.
- Application support - InControl's experienced Simulation Engineers will help you dealing with your modeling challenges.
- Full technical support - Full technical support is available to you via phone, e-mail, and online support system.
- Online support system - Full access to our support system including issue tracker, support, downloads, online community and much more.

Pedestrian Dynamics® simulation software is offered in the following license types:

- Pedestrian Dynamics® Viewer: Open, run and view available simulation models and applications.
- Pedestrian Dynamics® Runtime: Run customized and integrated applications
- Pedestrian Dynamics® Studio: Design, analyze & optimize
- Pedestrian Dynamics® Developer: Develop, integrate & distribute

Pedestrian Dynamics® Viewer
Our free of charge Pedestrian Dynamics® Viewer allows you to open, run and view any simulation model or application. This license is ideal for simulation modelers who like to offer their customer(s) a working simulation model that they can run, but not modify. In comparison to a movie (which displays a predefined sequence of frames) the user can decide which part of the model is highlighted or visualized (either 2D or 3D).

Pedestrian Dynamics® Runtime
Pedestrian Dynamics® Runtime provides you:

- A runtime license for the end-user application developed with Pedestrian Dynamics® Developer.
- The use and distribution of your integrated solutions to 3rd parties.

Pedestrian Dynamics® Studio
Pedestrian Dynamics® Studio allows:

- Development of crowd simulation models of any infrastructure
- Evaluation of the infrastructure in the complete lifecycle; from design to operation
- Crowd scenario analysis
- Optimization of infrastructure and process design
- Clear communication via 2D and 3D models, movies and output

Pedestrian Dynamics® Developer
Pedestrian Dynamics® Developer offers:

- All functionalities of Pedestrian Dynamics® Studio.
- A crowd simulation platform with an open architecture.
- Development and distribution of own end-user applications.
- Integration of the crowd simulation platform within your system.

TECHNICAL CAPABILITIES OF THE AVAILABLE PEDESTRIAN DYNAMICS® LICENSES TRIAL STUDIO

Pedestrian Dyncamics	Viewer	Studio	Developer	Runtime
Time limit	unlimited	subscribtion	subscribtion	subscribtion
Maximum Model Size	infinite	infinite	infinite	infinite
Develop models with automatic network creation		•	•	
Running simulations	•	•	•	•
Online updates, maintenance & support		•	•	•
Model import (CAD, CityGML and more)		•	•	
Instant 2D & 3D Visualization	•	•	•	•
Output Manager (Read)	•	•	•	•
Output Manager (Write)	•	•	•	
Movie Recorder	•	•	•	
Model architecture view			•	
Library architecture view			•	
Object, Application & GUI developer tools			•	
Debugging			•	
ArcGIS			•	•
External connections			•	•

4. Technology

ACADEMIC RESEARCH

Pedestrian Dynamics® can model large crowds of virtual pedestrians (agents) in realtime. To achieve these results, Pedestrian Dynamics® uses efficient crowd simulation algorithms and software, developed together with the Utrecht University (UU) in Utrecht, The Netherlands [1]. The collision avoidance algorithm is based on the vision based model developed by Moussaïd, Helbing and Theraulaz [6] Interested readers can find more details in the referenced scientific publications.

NAVIGATION MESH – EXPLICIT CORRIDOR MAP

During the simulation, agents should be able to efficiently find a path from their current position to any other position in the environment. A data structure that can answer these path planning questions is called a navigation mesh: a subdivision of the entire walkable space into connected polygonal areas.

One example of a navigation mesh is the Explicit Corridor Map (ECM) . The ECM is essentially a network (or a graph) consisting of vertices and edges. Hence, Pedestrian Dynamics® often refers to this data structure as the "ECM network". The edges of the ECM form the medial axis: a set of curves describing the middle of the walkable space. Figure 1a for an example environment; Figure 1b shows its medial axis.

Each ECM edge consists of nodes annotated with closest points, which induce a subdivision of the walkable space into polygonal areas. Hence, the closest-point annotations turn the ECM from a regular graph into a navigation mesh.
Figure 1c shows the closest-point data in our running example. Observe that the yellow line segments completely subdivide the free space into sub-areas.

(a) Environment (b) Medial axis (c) Explicit Corridor Map

Figure 1: (a) A simple environment with two obstacles, shown in dark gray. (b) The medial axis, shown in pink, runs through the middle of the walkable space. (c) Closestpoint annotations, shown in yellow, turn the medial axis into the ECM navigation mesh

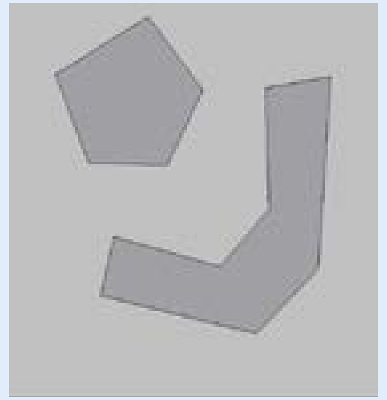


Figure 1: (a) environment

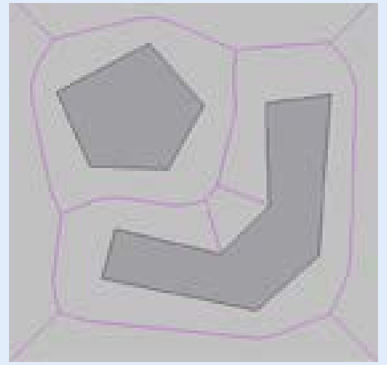


Figure 1: (b) medial axis

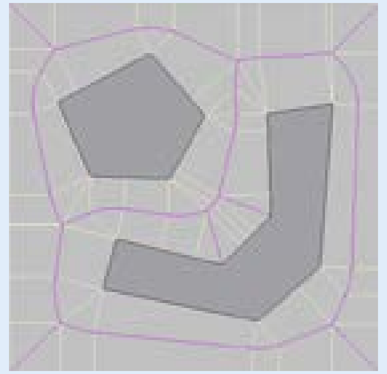


Figure 1: (c) Explicit Corridor Map

When planning a path to some goal position, an agent tries to find a route along the network's edges (i.e. along the medial axis) by using a modified A* algorithm. Thanks to the ECM's closest-point annotations, the resulting route is actually a corridor: a set of polygons and circle segments, describing the free space that the agent can use around the route.

Agents can move flexibly and efficiently through a corridor (see "Path following"), and they can use the free space to avoid other agents (see "Local collision avoidance"). Figure 2 shows an example of a corridor.

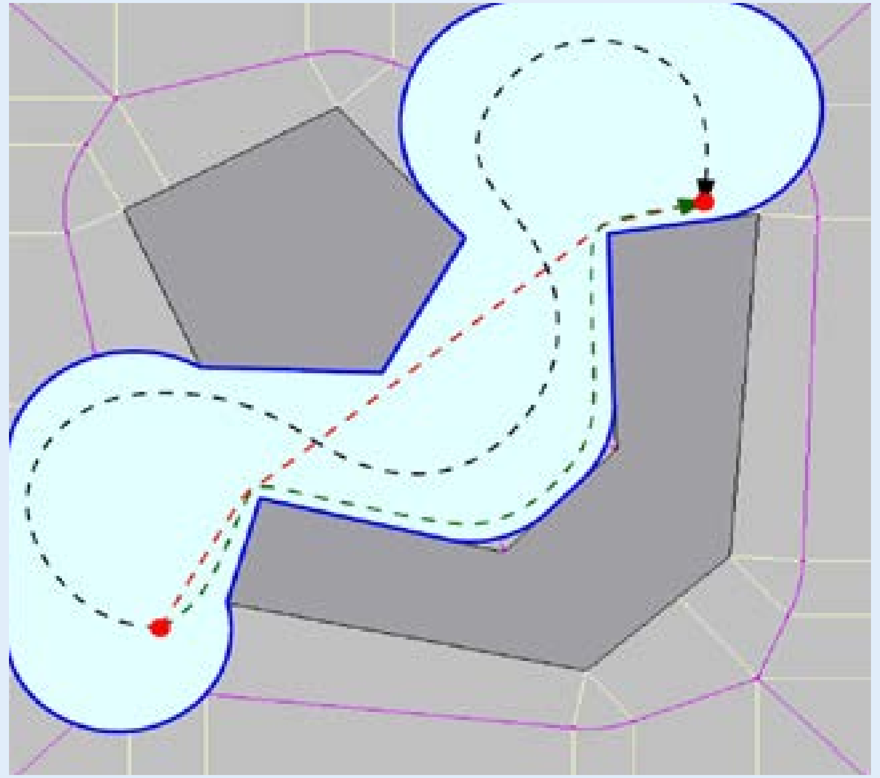


Figure 2 (c) Path Following

ADVANTAGES OF THE EXPLICIT CORRIDOR MAP

Next to its corridor flexibility, the ECM has more useful properties:

- It can be constructed quickly and automatically, given a set of layers and their obstacles. In Pedestrian Dynamics®, users can quickly build an arbitrary environment and then generate the routing network by pressing a single button.
- It has a small memory footprint: its size is proportional to the complexity of the environment.
- It supports multi-layered environments, in which multiple two-dimensional layers are connected, e.g. through staircases [3].
- It can plan paths for agents of various sizes, by using only a single data structure. Agents can decide for themselves whether or not a passage (an ECM edge) is wide enough for them to use.
- It can be annotated with more information about the environment, such as the local density (see "Density-based crowd simulation"), special edge costs (e.g. for preferring escalators over staircases), or temporary changes (e.g. staircases that become unavailable, or emergency doors that open up). such as the local density (see "Density-based crowd simulation"), special edge costs (e.g. for preferring escalators over staircases), or temporary changes (e.g. staircases that become unavailable, or emergency doors that open up).

In short, the Explicit Corridor Map is an efficient and flexible navigation mesh for crowd simulation.

ROUTE FOLLOWING - THE INDICATIVE ROUTE METHOD

Once an agent has planned a global route to its goal position (i.e. it has found a corridor), the agent should look for a way to move through its corridor. For instance, the agent can choose to stay on the left or right side of the corridor, or to follow the shortest possible path with some preferred clearance to obstacles. Figure 2 shows a number of options.

The so-called Indicative Route Method (IRM) [4] is a general framework that smoothly steers an agent through a corridor while following an indicated path (the indicative route). In each step of the simulation, the agent computes a desired velocity that will send the agent further along its indicative route. The agent may deviate from this desired velocity, e.g. when walking around other agents, as long as it does not leave its corridor.

In Pedestrian Dynamics®, users can set the options for this path planning phase for each agent profile. These settings can be found in "Agent input -> Agent profile -> Route following"

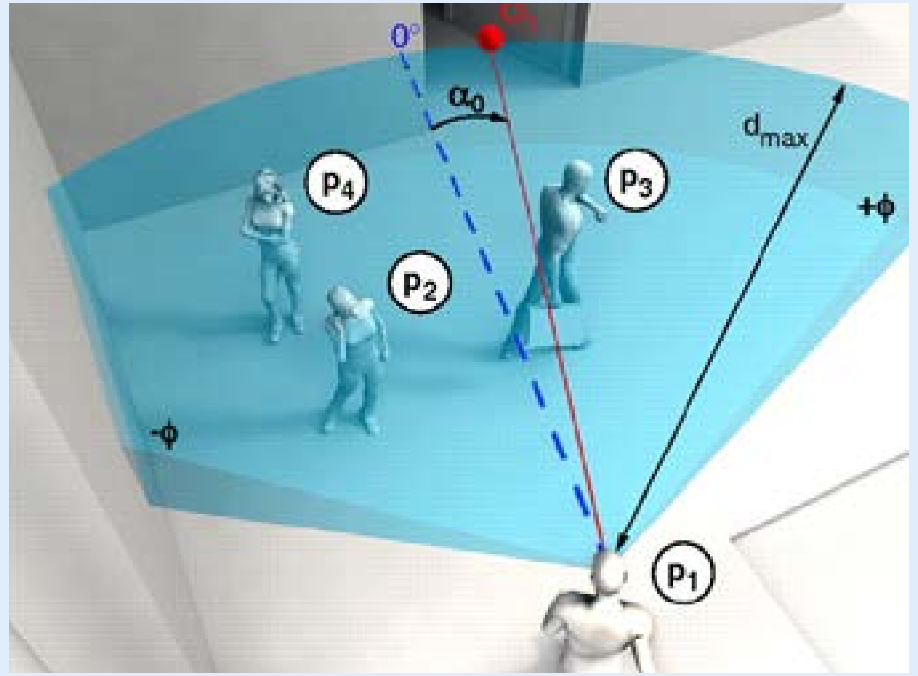
LOCAL COLLISION AVOIDANCE

As mentioned, path planning in corridors gives the simulated agents a lot of flexibility. Next to the described variety of indicative routes, a corridor also supports collision avoidance between agents. Collision avoidance can be a time-consuming task, but it increases the simulation's realism.

Each agent uses vision to detect which obstacles, both dynamic and static, it has to avoid. The vision is modeled as a cone-shaped field of view (FoV). The collision-avoidance algorithm in the ECM crowd simulator lets each agent choose a velocity that is close to its desired velocity (i.e. with a small difference in direction and speed), but that prevents them from colliding with others. Similarly, the agents can be blocked by local obstacles, such as temporarily closed doors. The collision avoidance algorithm is based on the vision based model developed by Moussaïd, Helbing and Theraulaz [6].

Newtonian force models are still not fully consistent with empirical observations and are often hard to calibrate. Therefore, Pedestrian Dynamics® uses a cognitive science approach, which is based on vision and behavioral heuristics. Guided by visual information, namely the distance of obstructions in candidate lines of sight, pedestrians apply two simple cognitive procedures to adapt their walking speeds and directions. For more detailed information see [6]. The model predicts the emergence of self-organization phenomena, such as the spontaneous formation of unidirectional lanes, stop-and-go waves, crowd compression, edge and wake effects and others.

In Pedestrian Dynamics®, users can switch agent collision avoidance on an off for the entire simulation, in "General settings -> Simulation". Other options (e.g. the size of the field of view) can be set for each type of agent. These settings can be found in "Agent input -> Agent profile -> Local behavior".

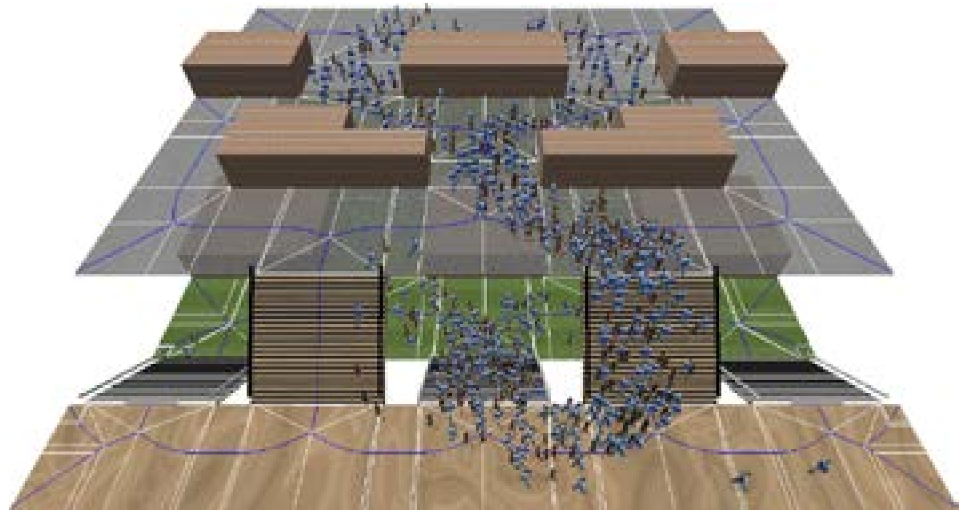


Note: Collision avoidance with "regular" obstacles (such as walls and buildings) can be computed very efficiently, because this information is stored in the corridors created by the ECM framework. A corridor is guaranteed to be walkable. As long as an agent stays inside its corridor, it cannot collide with stationary obstacles. The absence of finding the obstacles for collision checking is one of the reasons why ECM-based crowd simulation is efficient.

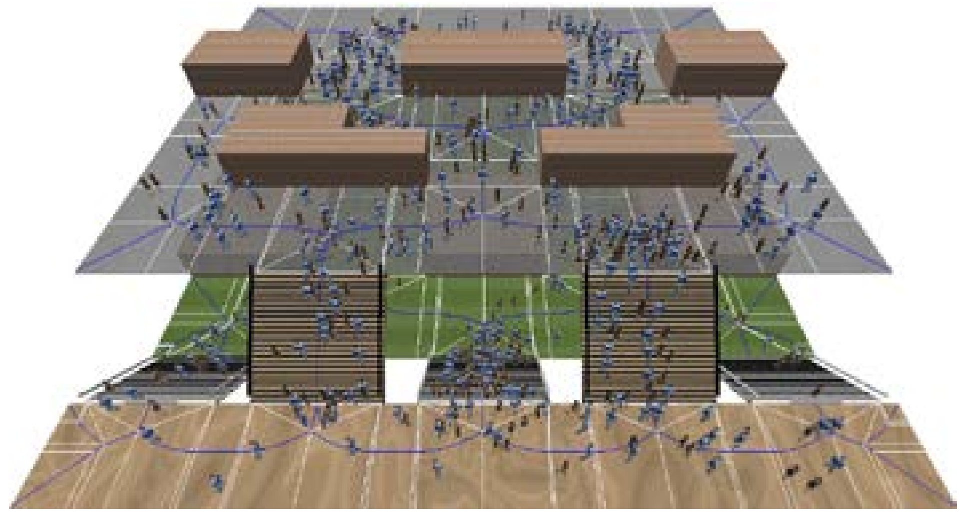
DENSITY-BASED CROWS SIMULATION

For pedestrian simulation tools such as Pedestrian Dynamics®, crowd density is very important. Many researchers have shown that agents generally walk at a slower pace when the local density is high. This relation can be captured in a density formula. Pedestrian Dynamics® contains a number of commonly used formulas; users are free to change them. In literature, crowd density is often measured in persons per square meter (p/m2), assuming that all agents have a certain (average) size. However, Pedestrian Dynamics® supports agents of various sizes: larger agents have a larger contribution to the crowd density. In our framework, the density is simply a value between 0 and 1 denoting how much of an area is occupied. To ensure that Pedestrian Dynamics® can still use density formulas from literature, the "General settings -> Simulation" window contains a setting for the "average agent area".

The Explicit Corridor Map supports route planning based on density [5]. Recall that each edge of the ECM denotes a set of polygonal areas through its closest-point annotations. In other words, every edge is associated to a walkable polygonal region. By keeping track of the crowd density in these regions, we approximate the density around each edge. A density formula translates this density to an expected walking speed, and an expected traversal time for the edge. The agents can use these traversal times when planning a route: this density-based crowd simulation lets agents avoid crowded regions, and it spreads the crowd among alternative routes in a natural-looking way. In Pedestrian Dynamics®, general density related parameters can be found in "General settings", and the routing preferences can be set for each agent type in "Agent input -> Agent profile -> Route planning".



Crowd simulation based on short path



Density based crowds simulation for a better and more realistic distribution

COMBINATION WITH PEDESTRIAN DYNAMICS®

Pedestrian Dynamics® includes a software module that builds the ECM and performs crowd simulation. In Pedestrian Dynamics®, the user can build an environment by defining layers and filling them with obstacles and infrastructural elements such as staircases (which are actually separate layers). The environment is then converted to a PRIX file: an XML description of the layers, their obstacles and their connections. The ECM generation software returns an ECMX file: an XML file describing the vertices and edges of the Explicit Corridor Map. Back in Pedestrian Dynamics®, users can visualize the ECM's edges, vertices, nodes and annotations in 2D and in 3D. When the simulation starts an ECMU file: an XML file describing specific edge properties is send to the crowd simulation module.

During the simulation, Pedestrian Dynamics® generates agents and determines their goals by using the activity locations and activity routes drawn by the user. Pedestrian Dynamics® sends the start and goal positions of agents to the crowd simulation module, which plans the actual routes in the ECM network. In each simulation step, the module returns a new velocity for each agent.

A model in Pedestrian Dynamics® can also contain incidents, which trigger changes in the availability of the ECM's edges. These changes are sent, again as an ECMU file, to the crowd simulator, so that agents can respond to them in real-time.

This decoupled approach is very powerful. Pedestrian Dynamics® generates agents and performs their global decision-making based on activities, without requiring knowledge of the ECM from the user. In turn, the ECM simulator computes actual paths and velocities, without having to bother about the "meaning" of the environment. Combined with hardware accelerations (such as multithreading), this simulation framework can model the movement of huge crowds in real-time.

REFERENCES

[1] Utrecht University - http://www.uu.nl/EN/

[2] R. Geraerts. "Planning Short Paths with Clearance using Explicit Corridors." In IEEE International Conference on Robotics and Automation (ICRA'10), pp. 1997- 2004, 2010.

[3] W.G. van Toll, A.F. Cook IV, and R. Geraerts. "Navigation Meshes for Realistic Multi-Layered Environments." In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'11), pp. 3526-3532, 2011.

[4] I. Karamouzas, R. Geraerts, and M. Overmars. "Indicative Routes for Path Planning and Crowd Simulation". In The Fourth International Conference on the Foundations of Digital Games (FDG'09), pp. 113-120, 2009.

[5] W.G. van Toll, A.F. Cook IV, and R. Geraerts. "Real-Time Density-Based Crowd Simulation." Computer Animation and Virtual Worlds (CAVW), 23(1):59-69, 2012.

[6] M. Moussaïd, D. Helbing, G. Theraulaz. "How simple rules determine pedestrian behavior and crowd disasters." Proceedings of the National Academy of Science(PNAS), 2011.

5. Verification and validation

Verifying and validating simulation models such as Pedestrian Dynamics® is a key step in evacuation and operation analysis of pedestrian infrastructures. It assists in the mitigation of uncertainty, leading to greater confidence in the model results and a better representation of reality. The following definitions of these processes are used in the remainder of this document, and were retrieved from the International Standards Organisation (ISO, 2008):

- Verification: 'the process of determining that a calculation method implemented accurately represents the developer's conceptual description of the calculation method and the solution to the calculation method';

- Validation: 'the process of determining the degree to which a calculation method is an accurate representation of the real world from the perspective of the intended uses of the calculation method'.

Based on the aforementioned definitions, the verification of Pedestrian Dynamics® is performed to demonstrate that the theoretical background used in the development of the model has been accurately implemented. Validation tests, on the other hand, are performed qualitatively to illustrate the level of realism that can be obtained from simulation models.

Due to the lack of reliable empirical data available, verification and especially validation can be considered ongoing processes, and efforts are constantly being made to design additional procedures for the verification and validation of simulation models. Nonetheless, the performed tests aim at assuring the ability of Pedestrian Dynamics when representing aspects of human behavior in a diverse range of scenarios, and are based on guidelines currently considered benchmarks for assessment of model capabilities and literature studies.

Crowd simulation software is used to evaluate the safety and performance of infrastructure and event areas. This makes the reliability of the results very important. Pedestrian Dynamics® is verified and validated in accordance with pre-specified, internationally recognized guidelines and literature on pedestrian and crowd dynamics. There are three main international institutions that define standard tests to assess pedestrian simulation software tools. These institutions and their most recent guidelines are listed below:

- International Maritime Organization (IMO) MSC.1/Circ. 1533
- National Institute of Standards (NIST) Technical Note 1822
- Richtlinie für Mikroskopische EntfluchtungsAnalysen (RIMEA) Version: 3.0.0

For more details on the performed verification & validation test and the theoretical background in literature of Pedestrian Dynamics® crowd simulation framework, please refer to the Verification & Validation document.

6. System Requirements

OPERATING SYSTEM

In order to run Pedestrian Dynamics©, you require a Microsoft Windows operating system on the application system. Pedestrian Dynamics® is proven compatible with:

- Microsoft Windows 10
- Microsoft Windows 11

Pedestrian Dynamics® is available as a 32-bit and 64-bit application.

HARDWARE

Pedestrian Dynamics® performs many heavy calculations to be able to find possible routes between the origin and destination of pedestrians. Some of these calculations are executed parallel over multiple processor cores in order to allow the user a smooth performance. A fast modern computer is therefor required. With Pedestrian Dynamics® it is possible to view the simulation in 2D and 3D, but visualizing many pedestrians require a good video card. Low-end or on-board video cards are too slow and will have a heavy impact on the overall performance of your simulation model. Both for calculations and for visualizations you need a more than average consumer computer. To give you an idea we the recommended specification of the computer that you need to properly (and smoothly) run simulation models with Pedestrian Dynamics®

RECOMMENDED

- Processor: 7th Generation (or higher)
- Memory: 16 Gb (or more)
- Hard Drive space: 250 Gb+
- Operating System: Windows 10 and 11
- Video Card: Professional or Gaming OpenGL

VIDEOCARD

To use Pedestrian Dynamics® to its full extent, it is recommended that you use a laptop or desktop with a major brand (e.g. NVIDIA or AMD) 3D graphics card with at least 4 Gb of (non-shared) RAM (for textures and frame buffer). Ask your hardware supplier for a chipset that supports native OpenGL.

7. Technical Specifications

Version information	
Current version	4.3
Year of Relese	2023

Installations	
Number of sold engine licenses	> 11.000
Number of universities using simulation engine	> 500

Support	
Annual Maintenance & Support contract	Yes
Maintenance & Support includes product updates	Yes
Support Channels	Website Community Issue Tracker (JIRA) E-mail Phone • Int +31 (0)30 670 3798 • USA: +1 601 266 61 83 Onsite
E-mail and Phone Support TImes	08:30 - 18:00 CET

Documentation	
Basic Tutorial	Yes
Advanced Tutorials	Yes
Help	Yes
Example Models	Yes
Video Tutorials	Yes

Documentation	
Available standard training courses	Studio & Developer
Training locations	Woerden (NL) & Hattiesburg (USA)
Onsite training possible	Yes

Simulation Objects	
Limit to max. number of simulation objects	No (depending on hardware specifications and license)
Ability to modify existing simulation objects	Yes (depending on license)
Ability to create simulation objects	Yes (depending on license)
Simulation objects contain spatial information	Yes

Modeling	
Adding simulation objects to model	Mouse click / Ability to add objects via code
Modeling paradigm	Object-oriented
Ability to use layers	Yes (depending on license)
Availability of pre-defined rules	Yes
Integrated with visualization	Yes (2D & 3D)
Automatic network creation	Yes (ECM)
Automatic route creation	Yes (IRM)

Simulation Run	
Real-time	Yes
As fast as possible	Yes
Custom speed	Yes
Run until stop time	Yes

Experimentation & Results	
Experimentation Wizard	Yes
Integrated output module	Density maps Density areas charts Frequence maps Travel times charts Travel times map Flow counter charts General statistics
Customized output	Yes
Result player	Yes
Record movie (avi)	Yes

Random Generator	
Number of independant random generators	2,147,483,647
Repetitive	Yes
Antithetic	Yes
Generator algorithm	Wichmann-Hill and Mersenne Twister

Distributions	
Bernoulli	Yes
Beta	Yes
Antithetic	Yes
Binomial	Yes
dUniform	Yes
Emperical	Yes
Erlang	Yes
Gamma	Yes
Geometric	Yes
Logistic	Yes
LogLogistic	Yes
LogNormal	Yes
NegBinomial	Yes
NegExp	Yes
PearsonT5	Yes
Normal	Yes
PearsonT6	Yes
Poisson	Yes
Random	Yes
Triangular	Yes
TriangularTop	Yes
Uniform	Yes
Weibull	Yes
Custom distribution	Yes

Visualization & Model import	
2D	Yes
3D	Yes
2D graphic formats	Microsoft Windows Bitmap > *.bmp, .rle, .dib* (Enhanced) Windows Metafile > *.emf, .wmf* Joint Photograph Experts Group > *.jpg, .jpeg, .jpe, .jfif* AutoCAD Drawing File > *.dwg* Autodesk Design Web Format > *.dwf* AutoCAD Drawing Exchange File > *.dxf* CityGML > *.gml* Graphics Interchange File > *.gif* HP Graphic Language File > *.hpgl, .hgl, .hpgl2* Targa Graphics Adapter File > *.tga, .win, .vst, .vda, .icb* Portable Map Graphic > *.pgm, .pbm, .ppm* Computer Graphics Metafile > *.cgm* Scalable Vector Graphics File > *.svg* Tag Image File > *.tif, .tiff, .fax* Adobe Photoshop File > *.psd, .pdd* Pointshop Pro File > *.psp* Portable Network Graphics File > *.pgn* Windows Icon > *.ico* PCX, RLE encoded image > *.pcx, .scr, .pcc* Autodesk Image > *.cel, .pic* Kodak PhotoCD > *.pcd*
3D graphic formats	VRML 1.0 and 2.0 > *.wrl* 3D Studio > *.3ds* CityGML > *.gml* AutoCAD Drawing File > *.dwg* Autodesk Design Web Format > *.dwf* AutoCAD Drawing Exchange File > *.dxf*
Ability to control 3D meshes	Yes
Texture support	Yes
Ability to create materials	Yes
Support for all geometric primitives	Yes
Custom camera positions	Yes
Perspective projection	Yes
Parallel projection	Yes
Camera settings	Field of view Near Plane Far Plane
Freehand camera	Yes
Target camera	Yes

Database Support	
ODBC	Yes (depending on license)
ADO	Yes (depending on license)
Real-time database access	Yes (depending on license)

Connectivity	
XML	Yes
ActiveX Server	Yes
ActiveX Client	Yes
OPC Client	Yes
Text files (.txt, .csv)	Yes
Communications ports DDE	Yes
Excel Word TCP/IP UDP	Yes
SAP IEEE 1516 (High Level Architecture) standard compliance	Yes
Custom DLL support	Yes

Customization	
Programming language	4DScript
Ability to change application forms	Yes (depending on license)
Ability to add user forms	Yes (depending on license)
Ability to add new functions	Yes (depending on license)
Ability to add new attributes	Yes (depending on license)
Ability to use variables	Yes (depending on license)
Simulation Engine OEM ready	Yes (depending on license)

Integration	
ArcGIS	Yes (depending on license)

System Requierements Recommended	
Processor	7th Generation (or higher)
RAM	16 Gb (or more)
Video Card	4Gb or more dedicated RAM
Hard disk	250 Mb free space

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